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Radiometric Calibration Changes For V6

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(reporting on work done by
Margie Weiler and Evan Manning)

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Radiometric Calibration V6
AIRS Science Team Meeting
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Outline

- **Introduction—why new radiometric calibration coefficients have been derived**
- **AIRS radiometric calibration equation**
- **Comparison of the pre-flight data analyses used to derive old (V5 and earlier) and new coefficients**
- **AIRS radiance differences, old vs. new**
- **Radiometry issues not addressed by the new set**
- **Plans for V6 and V7**
  - ***L1B radiometry will not change in V6***
  - ***The revised coefficients will be implemented in L1C as a research product***
  - ***Several issues still need work for V7***

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Introduction

- **In a 2008 SPIE paper, Tom Pagano showed that the AIRS radiometric calibration is excellent:**
  - ***based on the transfer of the NIST-traceable calibration of an external large-area blackbody (LABB) to the internal on-board calibrator (OBC)***
  - ***accuracy is predicted to be 0.2K, 3 sigma***
- **That paper reported planned adjustments to the calibration coefficients for PGE V6 which would ensure this level of accuracy**
- **This talk reports on a parallel investigation by Margie Weiler (with support from Evan Manning) that has resulted in further improvements to those coefficients**
- **The effects of these new coefficients should be an additional reduction in the estimated radiometric error**
- **The purpose is to improve the accuracy for climate trending. There is little or no effect on weather forecasting.**

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AIRS Radiometric Calibration Equation

$$N_{Sc} = \frac{a_0(\theta_j) + a_{1,i}(dn_j - dn_{sv}) + a_2(dn_j - dn_{sv})^2}{1 + p_r p_t \cos[2(\theta_j - \delta)]}$$

and

$$a_0(\theta_j) = P_{sm} p_r p_t [\cos 2(\theta_j - \delta) + \cos 2\delta]$$

- N_{Sc} = scene radiance
- P_{sm} = Planck radiation from the scan mirror
- θ_j = scan angle of footprint j
- dn_j = counts at footprint j
- dn_{sv} = smoothed counts at nearby space views
- p_r = polarization amount from scan mirror
- p_t = polarization amount from spectrometer
- δ = polarization phase angle in spectrometer
- a_0 = offset coefficient (scan angle dependent)
- a_1 = gain-related coefficient
- a_2 = non-linearity coefficient

In-Flight Calibration (L1B)

- dn_{sv} is calculated by smoothing space view measurements in 10 neighboring scans
- a_1 is determined dynamically from OBC-look data (averaged over each granule), corrected by a parameter (ε_{OBC}) that represents the effective OBC emissivity
- a_0 is determined dynamically from the scan angle, scan mirror temperature, and the polarization parameters
- That leaves 4 static parameters per channel that must be obtained prior to science processing (ε_{OBC}, a_2, $p_r p_t$, and δ)

Pre-flight Data Used To Determine the V5 Coefficients (1 of 2)

- During the AIRS ground T/Vac tests, measurements were made with AIRS viewing a NIST-traceable calibrated black body (LABB) at a series of temperatures, at two scan angles (near nadir and near -40º) separately for A and B detectors
  - *These tests are collectively called the "stepped blackbody tests"*
- The nadir data and -40° data were fit separately to second-order polynomials. The intercepts a_0 at the two scan angles were used to determine the polarization coefficients
  - *Because the results were noisy, the values of $p_r p_t$ were adjusted to better fit a model of the spectrometer*
- a_2 was calculated from the nadir data
- ε_{OBC} was determined from nadir data to force agreement between model radiances and OBC observations

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Pre-flight Data Used To Determine the V5 Coefficients (2 of 2)

- δ was set to 0 as described in Tom Pagano's SPIE paper
- The A-only and B-only coefficients were then combined and smoothed according to the states calculated from channel noise data during the tests
  - *Thus the old set does not have separate coefficients for A and B detectors*
- *Since launch, we have been using the single set of these parameters that was determined by the above analysis*

Revised Data Analysis (v6k VERSION)

- Tom's SPIE paper describes a parameter set v6k
- The major change from the V5 set was to remove the model-based adjustment to the polarization factor $p_r p_t$
- This resulted in improved residuals (calculated minus measured brightness temperature), mostly for the nadir data
- The work reported in this talk (mostly due to Margie Weiler) has made further improvements in the methodology

Revised Data Analysis (N40rab = new set) (1 of 2)

- **Ground test data called "rvs" (response vs. multiple scan angles, viewing a 308K blackbody) were fit simultaneously with all the stepped blackbody data**
  - ***That is, for the stepped blackbody data the nadir and -40° data were not fit separately, but instead both were included with the rvs data in two fits per channel (an A-only and a B-only fit)***
- **As in v6k, the model adjustment to the polarization factor $p_r p_t$ was dropped—values from the fits were used**
- **δ was not set to 0—the values that came out of the fitting process were preserved**

Revised Data Analysis (N40rab = new set) (2 of 2)

- **A-only and B-only coefficients were not combined into one set**
  - ***Instead, they were combined appropriately for each on-board gain table ever used in flight (3 so far with a 4th coming soon) (requires minor software change)***
- **The selection of footprints was improved and, the space look offsets used the same sliding 10-scan-linear-fit smoothing algorithm that is used in the current PGE**
  - ***Each scene and calibration footprint has a different space look value***
- **Used exact scan angles for each footprint**
- **Fit all data points rather than means for each test temperature**

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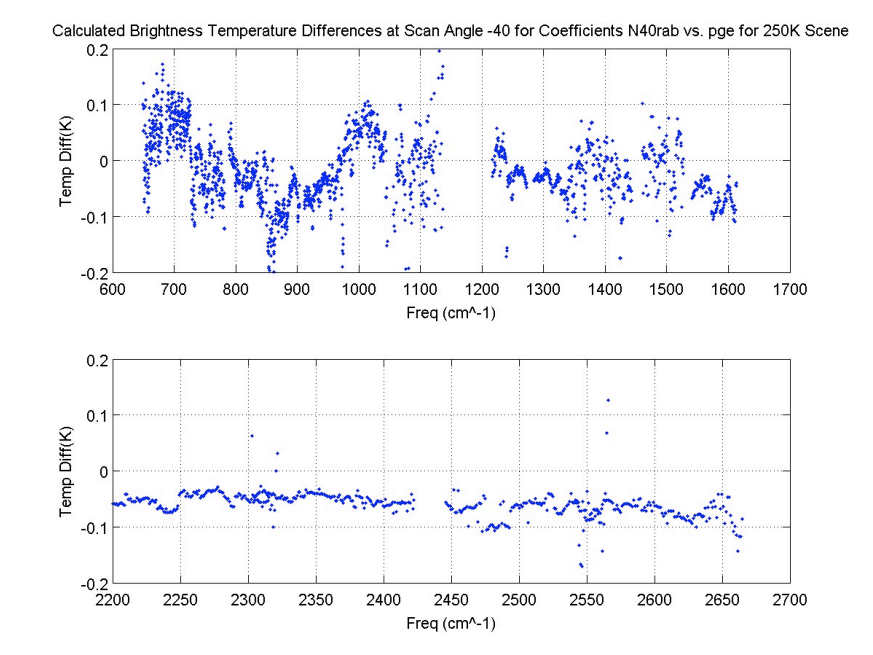
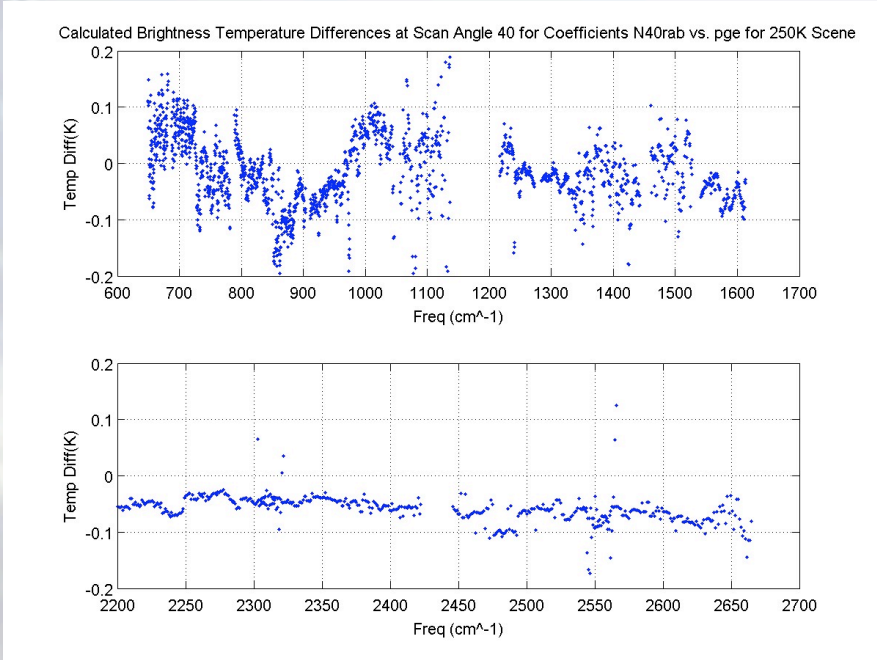
Predicted Changes In AIRS Radiances Are Less Than About 0.1k For 250k Scenes





Note: Some of the N40ab (=V6/L1C) - PGE (=V5) differences are due to the A/B smoothing done for V5 vs. separate A and B smoothing

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Comparison Of Polarization Parameter Fits (black = new set)

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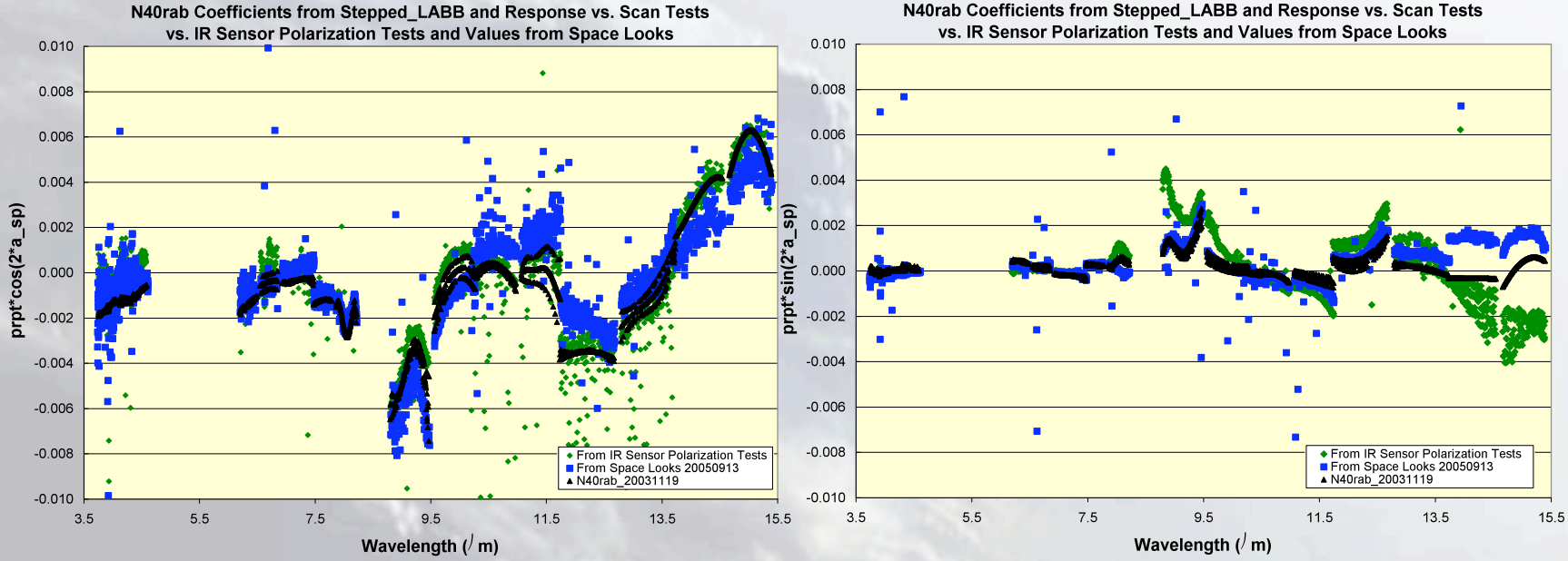

- **New parameters compare reasonably well with those from ground polarization tests (p_r from scan mirror test, p_t and δ from IR Sensor test)**
- **They also compare reasonably well with values from fits to space looks in flight**

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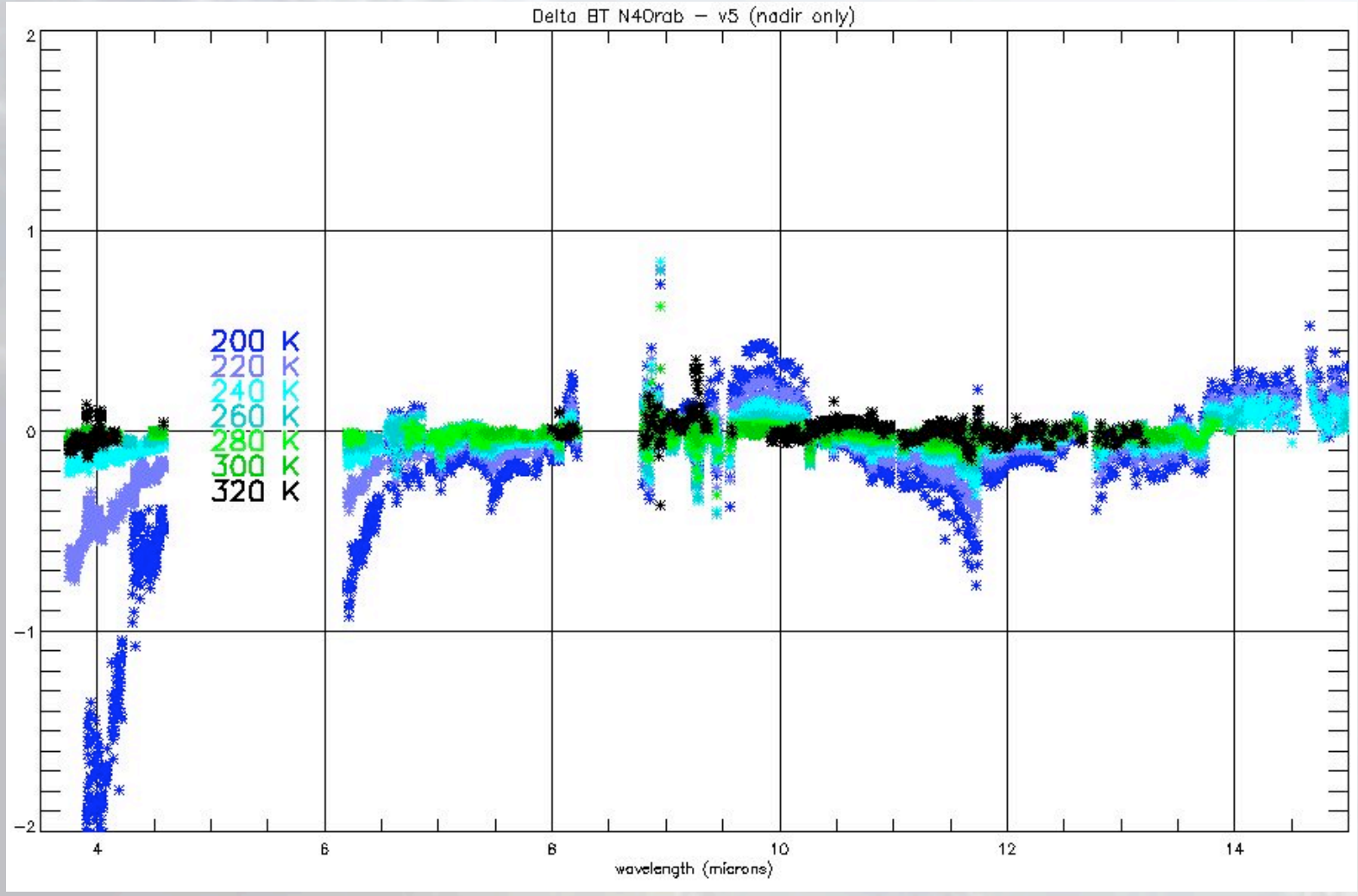
New (N40rab) vs Old (V5) Radiances vs. Wavelength



Implementation Plans And Discussion (1 of 4)

- As far as radiometry is concerned, V6 L1B will be the same as V5 L1b (old coefficient set used)
- The new coefficient set will be used in V6 L1C
- How V6 L1c will be packaged is still under discussion
  - *stand-alone programs to convert between old and new radiances will be made available*
  - *an L1C research product may be generated for all data OR*
  - *routines may be provided for users to generate their own L1C products on demand*

Implementation Plans And Discussion (2 of 4)

- Evan Manning will discuss the spectral calibration, noisy channel cleanup, and frequency resampling aspects of L1C in the next talk
- L1B products (calibrated radiances) will always be the primary L1 AIRS product, since they are NIST-traceable
- L1C products (cleaned up and resampled radiances) are helpful in a variety of applications, but their traceability to NIST standards is unclear

Implementation Plans And Discussion (3 of 4)

- **Several issues still exist in AIRS radiometry that have not been affected by the new coefficients and are still being studied**
  - In M8 there are significant differences in the resultant radiances using A-only channels versus B-only versus A +B
  - AIRS short-wave window channels show trends in deep convective clouds (very low scene temperatures) not seen by IASI or by either AIRS or IASI at Dome Concordia
  - Space looks and/or polarization parameters have changed slightly since launch
  - Unflagged pops exist

Implementation Plans And Discussion (4 of 4)

- The following two items may be related
  - *At very low scene temperatures, overlap channels and window channels that are expected to produce very similar brightness temperatures instead see differences of 0.5K or so*
  - *Correction of detector scene coverage non-uniformity (C_{ij}) has not yet been implemented*

Summary

- **Revised analysis of pre-launch data has determined a new set of calibration coefficients which fit the pre-flight data better than the old coefficients**
- **Their effect on AIRS radiances is significant for climate studies, but not for weather forecasting**
- **The new coefficients by themselves do not solve some small but nagging problems with AIRS radiometry**

For the future

- **Plan for V6 and V7**
  - ***L1B radiometry will not change in V6 and there will be no reprocessing of L1A or L1b at the GES DISC after V6 is delivered***
  - ***L1C, including the new calibration coefficients, will be labeled a research product***
  - ***Several issues (described earlier) still need work for V7***
- **In a forthcoming paper by Ken Overoye, Margie Weiler et. al., the new parameters will be incorporated into new estimates of the AIRS calibration accuracy**

Backup

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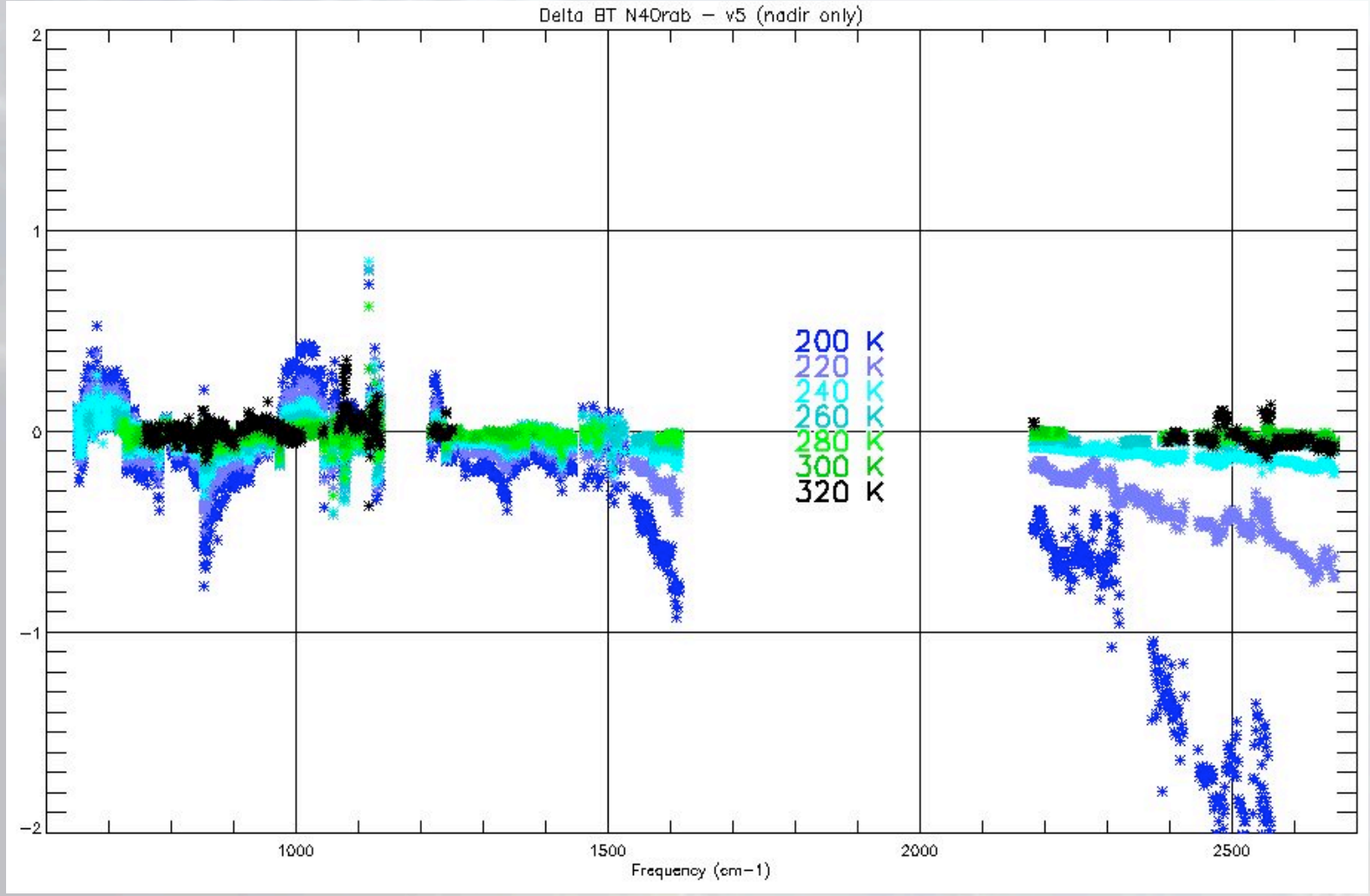
New (N40rab) vs Old (V5) Radiances vs. Frequency



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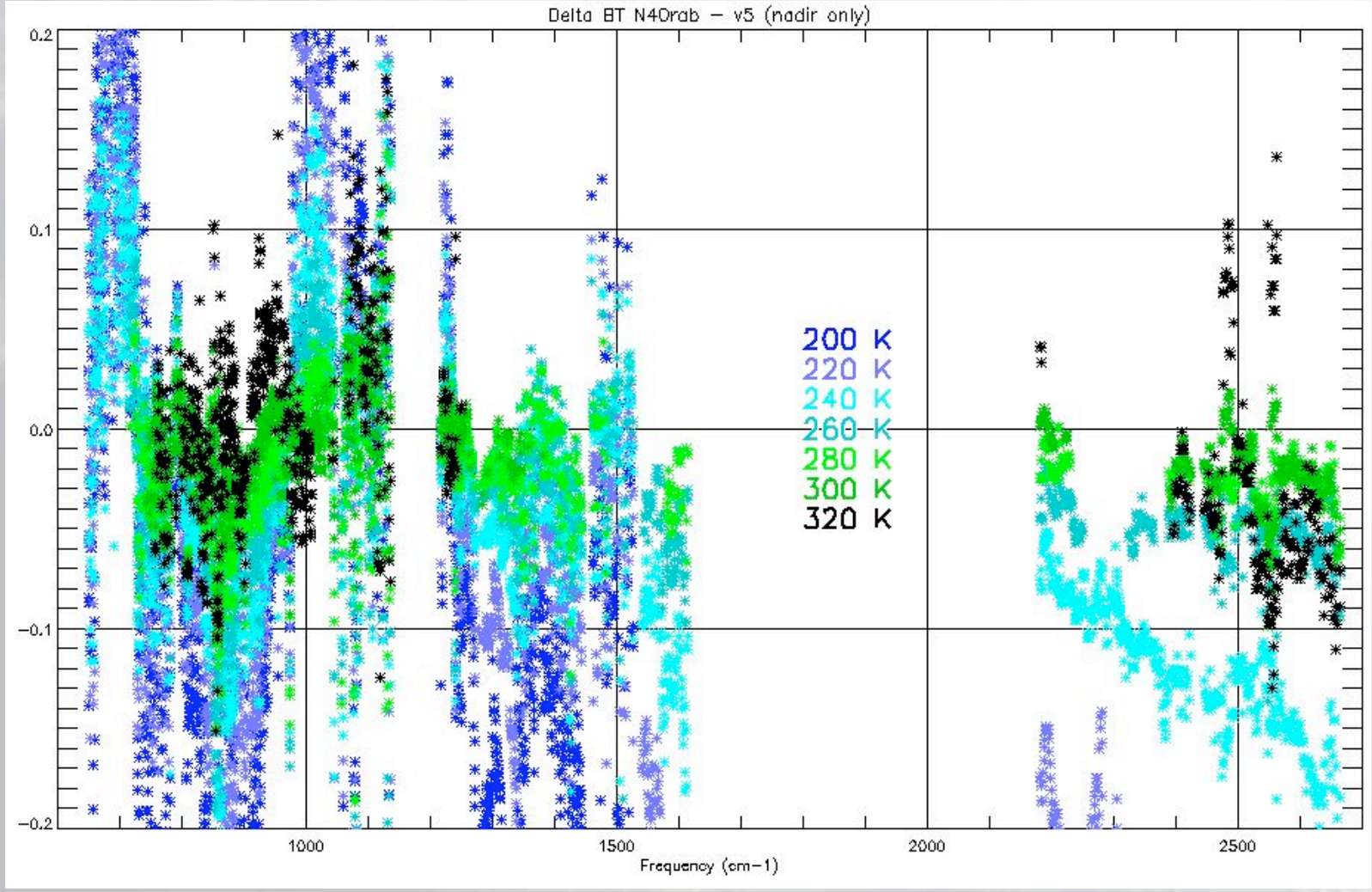
New (N40rab) vs Old (V5) Radiances vs. Frequency (zoomed in)



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New (N40rab) vs Old (V5) Radiances vs. Wavelength (zoomed in)